Space Weather Technical Forecast

Issued on Tuesday, 27 December 2022 at 13:15 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Risk of G1/Minor Storms throughout, mainly on 27 and 29 December. Chance of M-class flares. Active electron fluence risk declining.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Activity has been Moderate over the last 24hrs, with an M2.0 flare at 27/0054UTC and M1.0 flare at 27/0814UTC, both likely from AR3176, as well as continued low energy C-class flares mainly from AR3169. There are six sunspot groups on the disc. The previous most dominant regions, AR3169 and AR3171 both continue to simplify slightly, but are still relatively large and complex. Ex-AR3172 in the southern hemisphere has now faded to plage, and AR3175 also in the south has declined. AR3173 has remained stable. AR3176 has shown the most distinctive evolution, and is now classified provisionally as Dki/Beta, although the foreshortening due to the viewing angle on the northeast limb continues to make a clear classification difficult.

No Earth directed CMEs detected in available imagery.

Solar Wind / Geomagnetic Activity: Solar wind speeds have followed a generally steady trend around 500-550km/s. Density average to just above average. Total magnetic field strength generally weak to moderate averaging around 8nT following drop from a peak around 10nT at the start of the period. The north-south component, Bz, has been similarly weak to moderate averaging around -7nT to 7nT following a minimum around -10nT at the start of the period. since 26/2200UTC it has been persistently negative. Phi angle was mainly positive. Geomagnetic activity reached G1/Minor storm levels between 26/1200-1500UTC, before declining to Quiet to Active levels. Analysis of data suggests that the Earth was subject to a weak CME passage during the the start of the period.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 remained at Background levels.

High energy electron flux (greater than 2 MeV), started at high levels, peaking at 4.55e3 pfu at 26/0915UTC. This then sharply declined to background levels by 26/1500UTC in the presence of the effects of the suspected CME. Despite a brief jump to high levels, values have continue to decline to moderate counts by the end of the period, on a declining trend. Electron fluence has followed a declining trend, recording 7.06e7 integrated pfu at 25/2359UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is forecast to be at predominantly Low levels, but with a chance of occasional moderate activity from current sunspots, and those rotating onto the eastern limb.

Solar Wind / Geomagnetic Activity: Two CMEs currently forecast to potentially affect the Earth over the next four days. The first, from an eruption early on the 24 December, may arrive some time during day 1 (27 December), with one from the 25 December potentially arriving on day 3

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(29 December), though confidence for both features is relatively low.

A further high speed stream from coronal hole 59 is forecast to connect to Earth on day 3 (29 December), with effects persisting into day 4 (30 December).

Geomagnetic activity is forecast to be mainly Unsettled to Active on day 1 (27 December), with a risk of G1/Minor Storm intervals. Generally Unsettled on day 2 (28 December), but with a risk of elevated geomagnetic activity due to continuing CME effects or a possible early connection to coronal hole 59, with this considered more likely on day 3 (29 December) where there is a chance of Active to G1/Minor Storm intervals. The forecast is currently uncertain for 30 December with continuing HSS effects likely.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels throughout, with a daily slight chance of reaching S1 levels.

High energy electron flux (greater than 2MeV) forecast is low confidence with the current downward trend likely to be variable. Forecast geomagnetic activity and high speed streams are considered likely to generally suppress electron flux values at times through the next three days, with any recovery most likely on day 4 (30 December). There is a chance of electron fluence values reaching the Active threshold, but with limited confidence.

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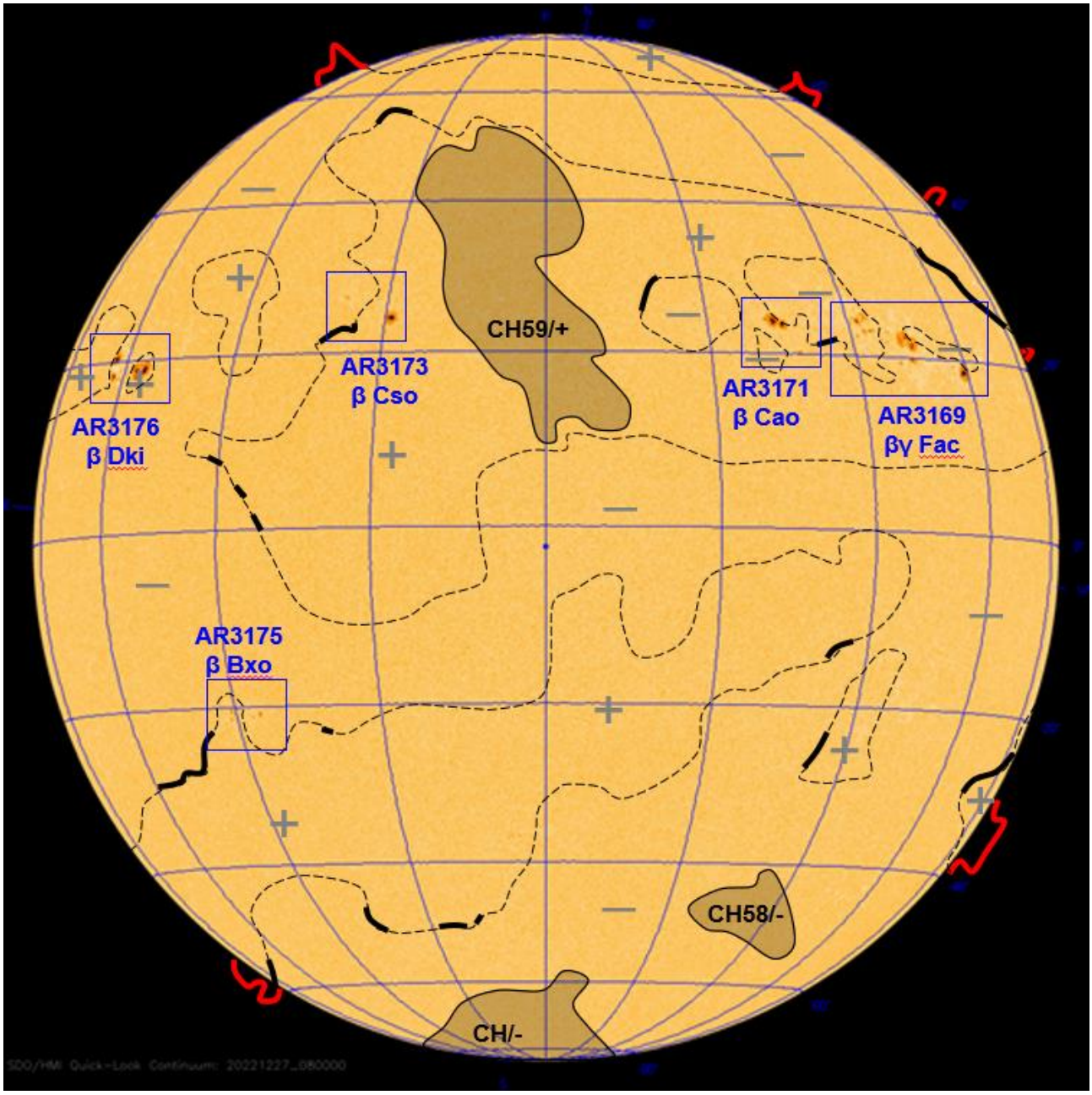
Figure 1. Solar Analysis Valid 27/0800UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

Two CMEs currently forecast to potentially affect the Earth over the next four days. The first, from an eruption early on the 24 December, may arrive some time during day 1 (27 December), with one from the 25 December potentially arriving on day 3 (29 December), though confidence for both features is relatively low. No other CMEs currently assessed as Earth directed.

The Earth may still be being affected by the declining high speed streams from coronal holes 56 and 57. As these were weakening feature any effects may have been masked by possible CME arrival yesterday. The larger coronal hole 59 may then connect with the Earth either late on 28 or more likely during 29 December, based on a potential high speed stream of between 500-600km/s though significant differences compared to the last rotation in this feature make precise forecast difficult.

Geomagnetic activity is forecast to be mainly Unsettled to Active on day 1 (27 December), with a risk of G1/Minor Storm intervals. Generally Unsettled on day 2 (28 December), but with a continued risk of elevated geomagnetic activity due to CME effects or a possible early connection to coronal hole 59, but this considered more likely on day 3 (29 December), where there is a chance of Active to G1/Minor Storms. The forecast is currently uncertain for 30 December with continuing HSS effects likely.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	60	30	40	30
Strong	G3	No	5	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
24/1415UTC	Partial	Potentially AR3169	NE quadrant	620km/s	27 December	Low confidence
25/1245UTC	Partial	AR3169	NE quadrant	520km/s	29 December	Low confidence

Figure 2: Latest ENLIL ensemble output, showing potential CME glancing blow 27th/29th and HSS effects into 29th/30th though note ENLIL considered perhaps slightly too late with this.

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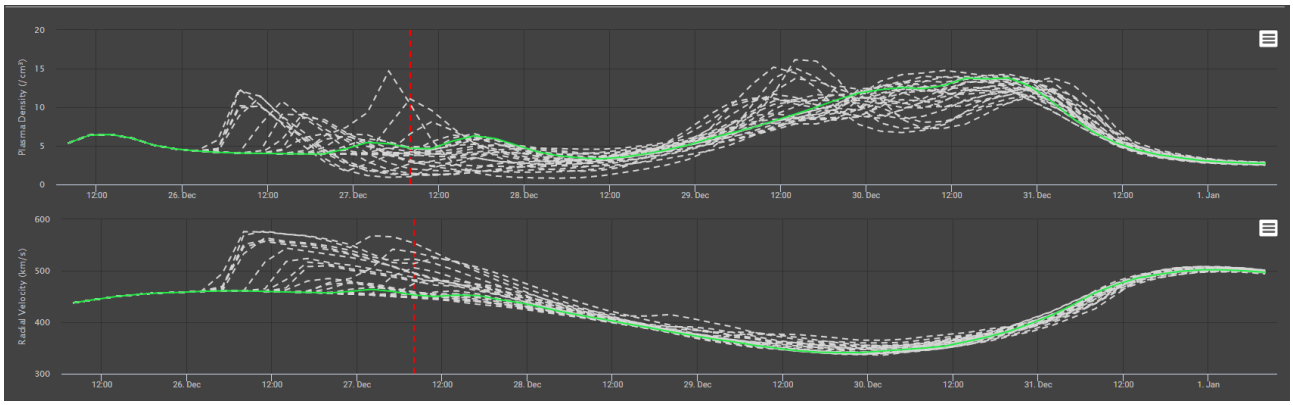

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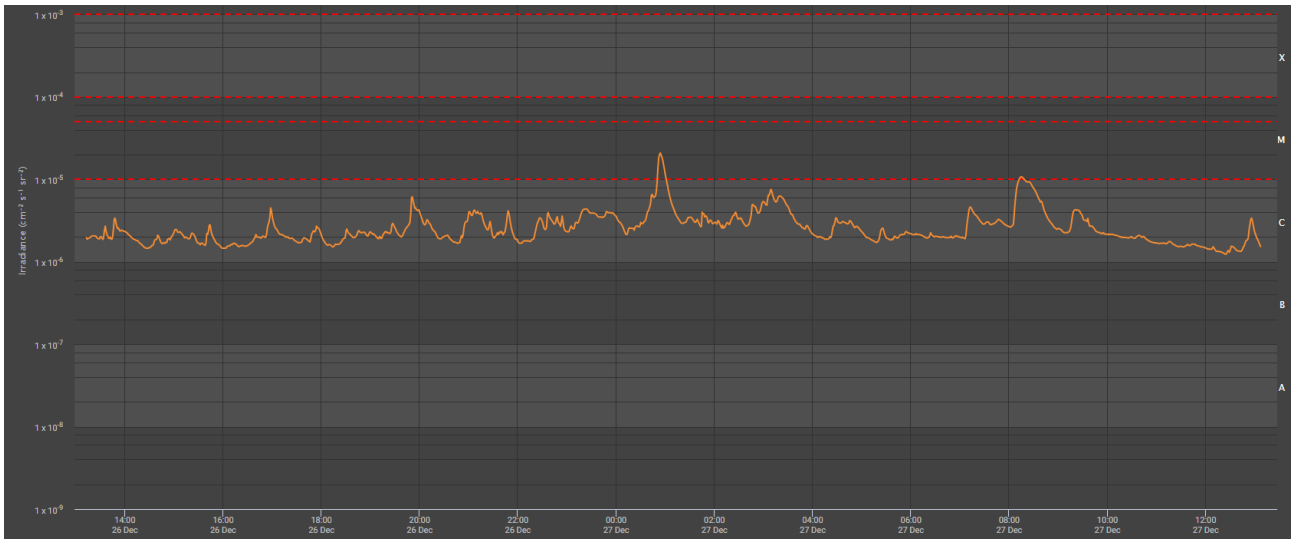
Radio Blackouts - X-Ray Flares:
Solar activity is expected to be mainly Low through the next four days, but with a heightened risk of occasional M-class flares giving moderate activity. The most likely source region for larger flares is now the rapidly developing, but difficult to analyse AR3176, close to the northeast limb. This is now classified provisionally as Dki/Beta, although the foreshortening due to the viewing angle on the northeast limb continues to make a clear classification difficult. AR3169 also continues to give frequent low energy C-class flares, with the potential for more activity. The production of a number of CMEs just beyond the eastern limb and the observation of far sided bright flux regions suggest a trend for more complex regions to rotate onto the disc. There is a very slight, but above background chance of isolated X-class flares.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	40	40	40	40
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: Last 24hrs GOES 17 X-ray trace



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Solar Radiation Storms - (High Energy Protons):
The high energy proton flux (greater than 10 MeV) is expected to remain generally at Background levels.

Forecast probabilities remain at a slight chance due to the possibility of any larger flares perhaps from AR3169, although this spot seems to have developed a tendency to discharge its energy regularly and at low levels, with no evidence as yet of any proton enhancements. AR3176, which is rapidly evolving in complexity, may also demonstrate a risk of M-class flares through the next four days.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

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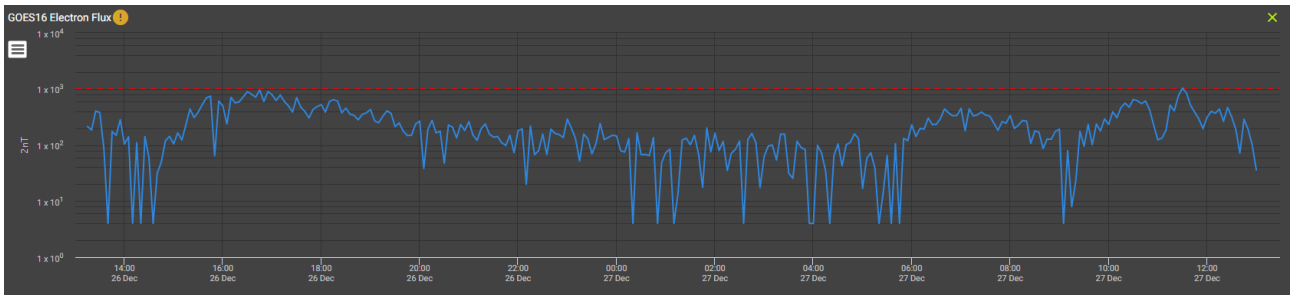
High Energy Electrons Event (≥ 2MeV):
High energy electron flux (greater than 2MeV) has been following a variable trend through the last 12 hours, having previously been at high levels prior to the recent geomagnetic storming. This is likely to be part of diurnal variation, exacerbated by the recent G1/Minor Storms. This trend of variable but occasionally moderate to high (1e3 pfu) levels of electron flux is likely to continue during 27 and 28 December in the absence of significant geomagnetic activity, which could distort the belts and redistribute electrons. The likely onset of a high speed stream from coronal hole 59 on 29 December may initially distort the belts, leading to an observed reduction in electron counts at GEO, which may then continue through into 30 December, depending on the strength of the high speed stream.

Electron fluence is following a slight downward trend, with this expected to continue through 27 December in a more muted electron flux environment compared to the previous 24 hours. The remaining of the forecast period is subject to the caveats mentioned above, with the likelihood of increased geomagnetic activity and belt distortion biasing the forecast to a lower likelihood of exceeding the Active (1e8 integrated pfu) threshold through the next three days, with a slight increase then possible on 30 December.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	50	50	30	30
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 4: Last 24hr GOES16 Electron Flux



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